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A3_2 Sucking the sea dry

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Abstract

This paper discusses the possibility of removing water from the earth into space using only capillary action. The paper finds that a capillary of radius 2.332×10^{-10}m would be required. This would mean that, though theoretically possible, it is not realistically plausible to create.

Introduction

Many strange and elaborate plans have been devised for dealing with the threat of global warming. This paper discusses the possibility of removing the excess water, created by the effects of global warming causing the sea levels to rise, by removing it to space, as defined by the Kármán line (100km)[1], via a tube using only capillary action. The paper will discuss the size a tube would have to be made to achieve such a result, adjusting for the decrease in pressure and temperature with height.

Theory

To work out the size of the tube, the equation for the height that a capillary would be able to raise a liquid [2] to is rearranged for the radius r, to get equation (1):

$$h = \frac{2\gamma cos\theta}{\rho g r},$$

$$r = \frac{2\gamma cos\theta}{\rho g h}, (1)$$

where h is the height of the tube (taken as 100km), γ is the liquid air surface tension, θ is the contact angle, ρ is the density of the liquid, g is acceleration due to gravity and r is the radius of the tube.

The value of γ is dependent on the temperature and molar volume of the liquid [3].

$$\gamma = \frac{k(T_c - T)}{V^{\frac{2}{3}}}, (2)$$

where k is the associated constant, T_c is the critical temperature, the point at which surface tension would become 0 $(647K)$ [4], T is the temperature and V is the molar volume. The temperature of the atmosphere varies greatly with altitude, often residing below the freezing point for water $(\sim 273K)$. Therefore, insulation and/or heating the tube would be required to keep the temperature above freezing, meaning the temperature variation throughout the tube may be discounted and the temperature can be taken as approximately zero (273K). Therefore, given a constant of $k = 2.10 \times 10^{-7}$JK^{-1}mol$^{-2/3}$, and a molar volume of $V = 18$ml mol^{-1}, (which gives 1.80×10^{-5}m^{-3} mol^{-1}); results in the value of γ being

$$\gamma = 0.114.$$

The change in density due to the decreasing pressure also needs to be accounted for. Equation (3) is the equation for calculating the change in density due to pressure [5].

$$\rho_1 = \frac{\rho_0}{1 - \frac{P_1 - P_0}{E}}, (3)$$

where ρ_0 is a known density measured at a point P_0, and ρ_1 is the density at a point P_1. E is the bulk modulus fluid elasticity [5]

($E = 2.15 \times 10^9$Nm^{-2}). This gives the water density at the top of the capillary tube as

$$\rho_1 = 999.820kgm^{-3};$$

given the sea-level density of water at 273k [6], $\rho_0 = 999.8675kgm^{-3}$ and the difference between the pressure at sea level, 101.3kPa (P_0), and space, ~0.032Pa (P_1) [1]. Due to the number of significant figures used for the rest of the article, $\rho_1 \sim \rho_0$ to any degree of accuracy. Substituting the values calculated for ρ and γ back into equation (1), where the contact angle for a glass tube is $0^\circ \rightarrow cos\theta = 1$, gives:

$$r = 2.33 \times 10^{-10}m.$$

Conclusion

While theoretically possible, the ability to manufacture a capillary tube with this constant internal radius for the required length makes this method of removing water from a planet impractical. Additionally, the rate at which such a device would remove the water would be extremely slow, due to the limitation of the flow rate from the limited radius, and the vertical distance the water would be required to travel. Therefore many such devices, perhaps bundled together, may be enough to extract a considerable amount of material from the ocean.

References

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